US008411202B2

(12) United States Patent
Mori et al.

(10) Patent No.: US 8,411,202 B2
(45) Date of Patent: Apr. 2, 2013

(54) **AUTOMATIC GAIN CONTROL CIRCUIT IN VIDEO SIGNAL PROCESSING DEVICE**

(75) Inventors: **Hirotoshi Mori**, Gunma-ken (JP); **Hiroyuki Ebinuma**, Fukaya (JP)

(73) Assignees: **Sanyo Semiconductor Co., Ltd.**, Gunma (JP); **Semiconductor Components Industries, LLC.**, Phoenix, AZ (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1156 days.

(21) Appl. No.: **12/249,528**

(22) Filed: **Oct. 10, 2008**

(65) **Prior Publication Data**

US 2009/0096926 A1 Apr. 16, 2009

(30) **Foreign Application Priority Data**

Oct. 11, 2007 (JP) 2007-265255

(51) **Int. Cl.**
H03M 1/12 (2006.01)

(52) **U.S. Cl.** **348/572**; 348/678

(58) **Field of Classification Search** 348/572, 348/678, 752, 571
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,790,706	A *	2/1974	Gubala et al.	348/572
4,434,439	A *	2/1984	Steckler et al.	348/572
4,642,694	A *	2/1987	Yamagishi et al.	348/790
4,827,191	A *	5/1989	Chapman	341/132
5,210,610	A *	5/1993	Kanashiki et al.	348/672
6,002,445	A *	12/1999	Urayama	348/572
6,195,133	B1 *	2/2001	Bae	348/678
6,219,107	B1 *	4/2001	Renner et al.	348/678
6,518,998	B1 *	2/2003	Christoff et al.	348/216.1
7,265,795	B2 *	9/2007	Ohyama et al.	348/675
7,355,656	B2 *	4/2008	Yoshida	348/678
7,362,382	B2 *	4/2008	Akiyama	348/678
7,580,081	B2 *	8/2009	Tamano et al.	348/678
7,589,795	B2 *	9/2009	Wu et al.	348/572
8,089,562	B2 *	1/2012	Okada et al.	348/678

(Continued)

FOREIGN PATENT DOCUMENTS

JP	07015684 A	*	1/1995
JP	7015684 A		1/1995

(Continued)

OTHER PUBLICATIONS

Noide et al, Amplitude control circuit, Jan. 1995, Sony Corp. (NPL translation of JP 07015684A).*

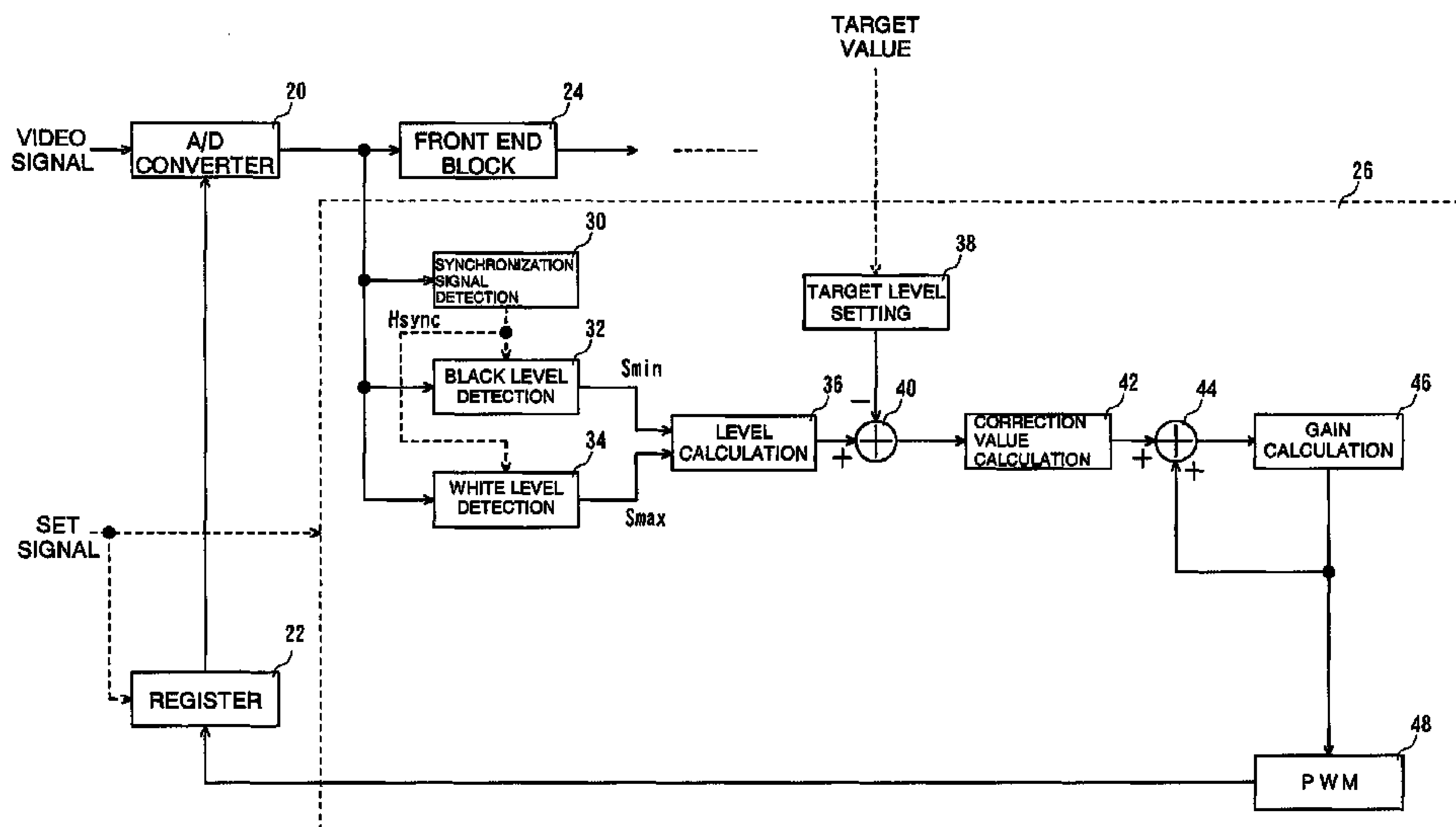
(Continued)

Primary Examiner — Jefferey Harold
Assistant Examiner — Humam Satti
(74) *Attorney, Agent, or Firm* — Osha Liang LLP

(57) **ABSTRACT**

In an automatic gain control circuit comprising a black level detecting unit which detects a black level from a video signal, a white level detecting unit which detects a white level from the video signal, and an analog-to-digital converter which adjusts a dynamic range of the video signal based on a difference value between the black level and the white level, a video signal for adjustment including a black level which indicates a minimum brightness of a video image and a white level which indicates a maximum brightness of the video image is input and the dynamic range is adjusted.

2 Claims, 6 Drawing Sheets



200

U.S. PATENT DOCUMENTS

2003/0227571	A1 *	12/2003	Movshovish et al.	348/691
2005/0062890	A1 *	3/2005	Yoshida	348/572
2005/0185100	A1 *	8/2005	Akiyama	348/678
2006/0007353	A1 *	1/2006	Matsutani et al.	348/441
2008/0043147	A1 *	2/2008	Choi	348/572
2008/0192131	A1 *	8/2008	Kim et al.	348/294

FOREIGN PATENT DOCUMENTS

JP	8265667	A	10/1996
JP	2005-094678	A	4/2005

OTHER PUBLICATIONS

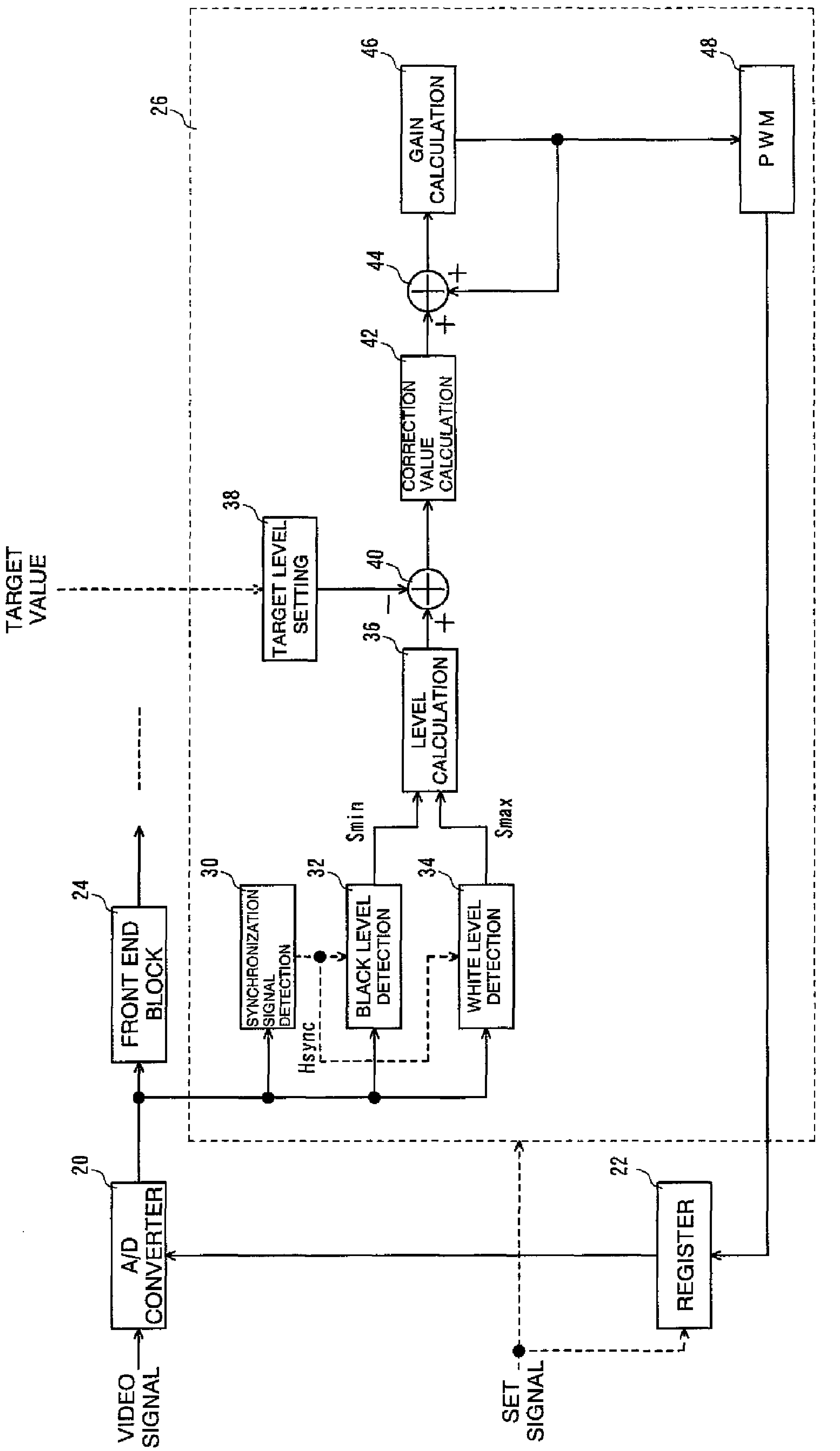
Japanese Office Action for Application No. 2007-265255, mailed on Aug. 2, 2011 (4 pages).

esp@cenet Patent Abstract for Japanese Publication No. 2005-094678, publication date Apr. 7, 2005. (1 page).

esp@cenet Patent Abstract for Japanese Publication No. 7015684, publication date Jan. 17, 1995. (1 page).

esp@cenet Patent Abstract for Japanese Publication No. 8265667, publication date Oct. 11, 1996. (1 page).

* cited by examiner


VIDEO SIGNAL
A/D CONVERTER
20
FRONT END BLOCK
24
SYNCHRONIZATION SIGNAL DETECTION
30
BLACK LEVEL DETECTION
32
WHITE LEVEL DETECTION
34
Hsync
Smin
Smax
LEVEL CALCULATION
36
TARGET VALUE
TARGET LEVEL SETTING
38
40
CORRECTION VALUE CALCULATION
42
44
GAIN CALCULATION
46
PWM
48
26
REGISTER
22
SET SIGNAL

200
FIG. 1

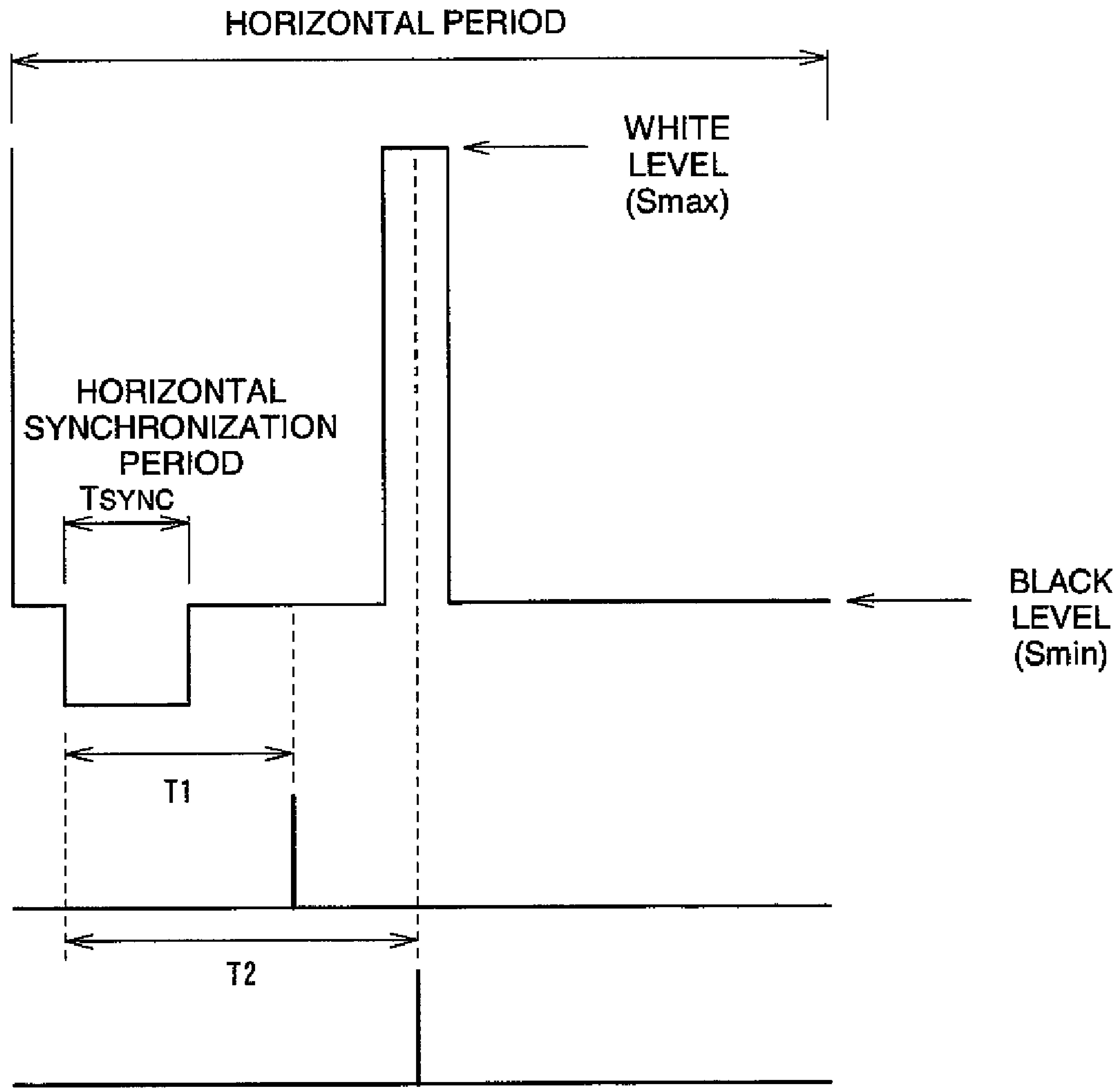

HORIZONTAL PERIOD
WHITE LEVEL (Smax)
HORIZONTAL SYNCHRONIZATION PERIOD
TSYNC
BLACK LEVEL (Smin)
T1
T2

FIG. 2

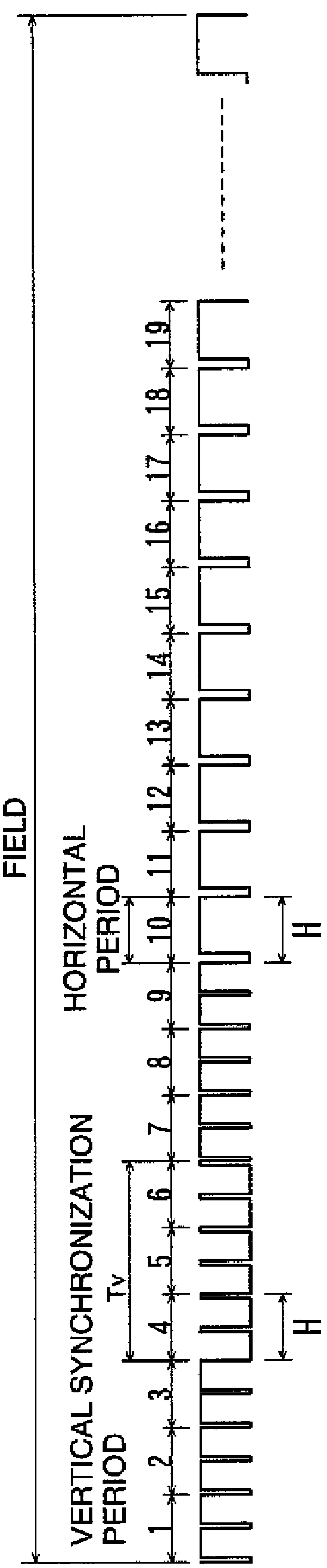

FIELD
HORIZONTAL PERIOD
VERTICAL SYNCHRONIZATION PERIOD
Tv
H
H
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

FIG. 3

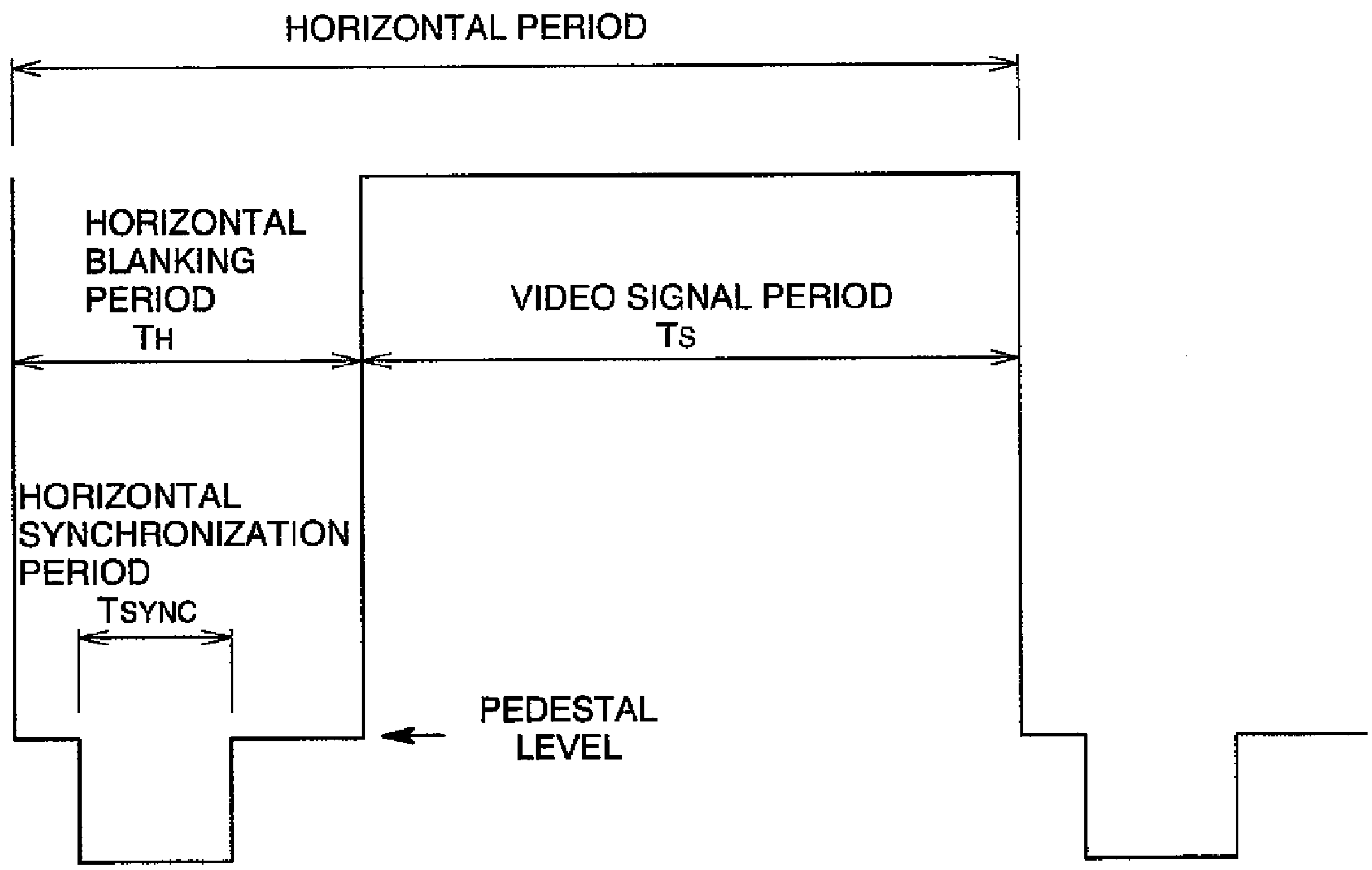
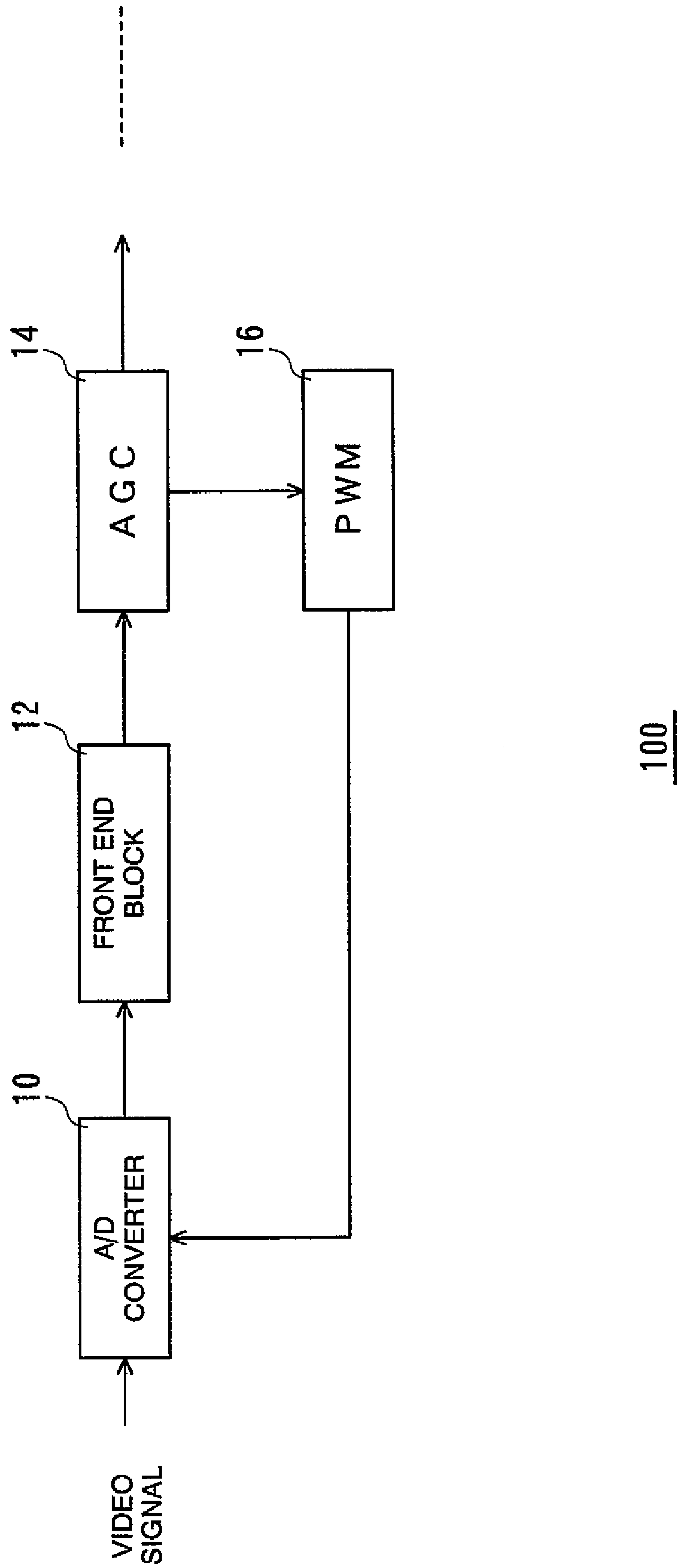
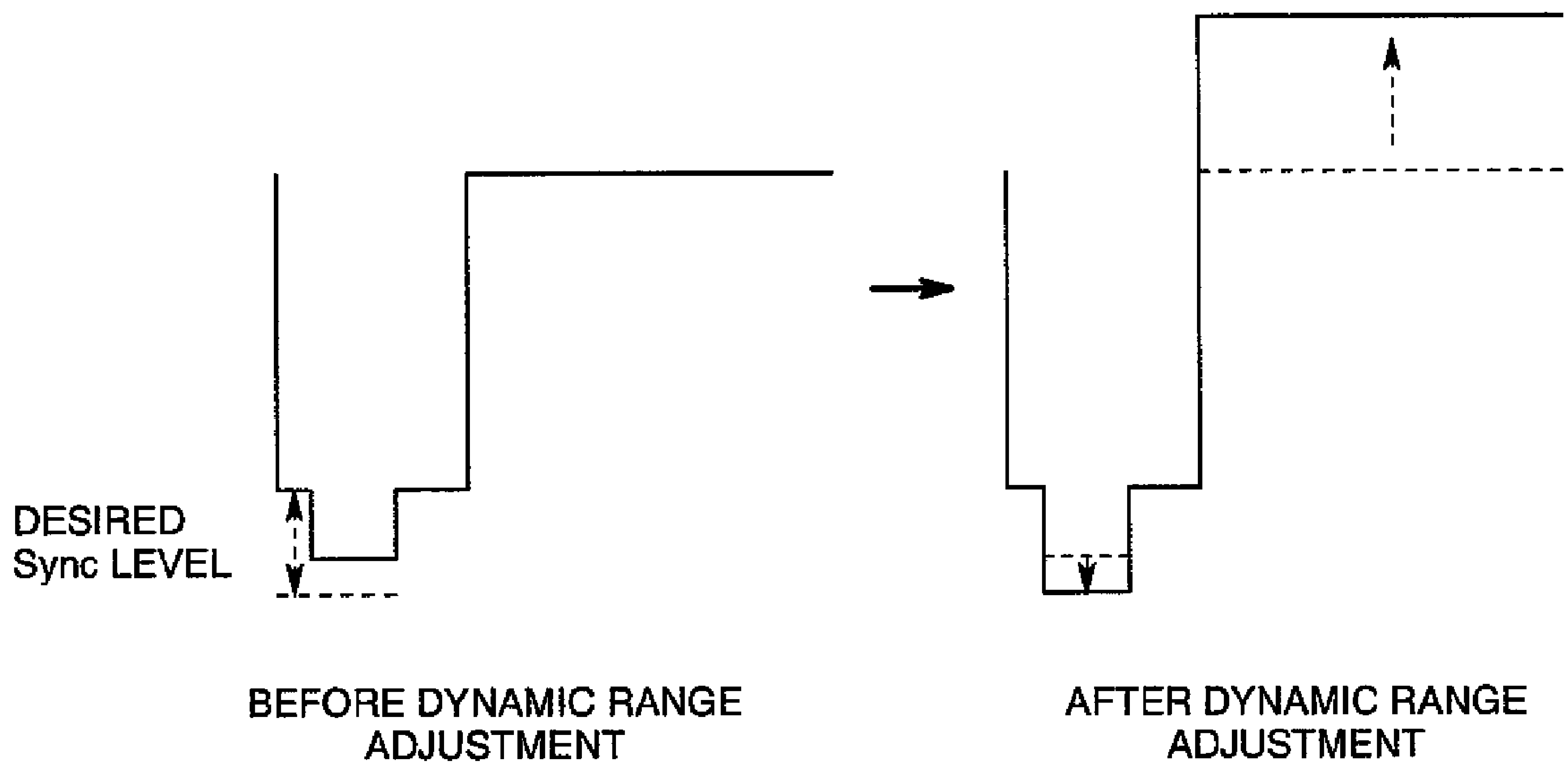

HORIZONTAL PERIOD
HORIZONTAL BLANKING PERIOD
TH
VIDEO SIGNAL PERIOD
TS
HORIZONTAL SYNCHRONIZATION PERIOD
TSYNC
PEDESTAL LEVEL

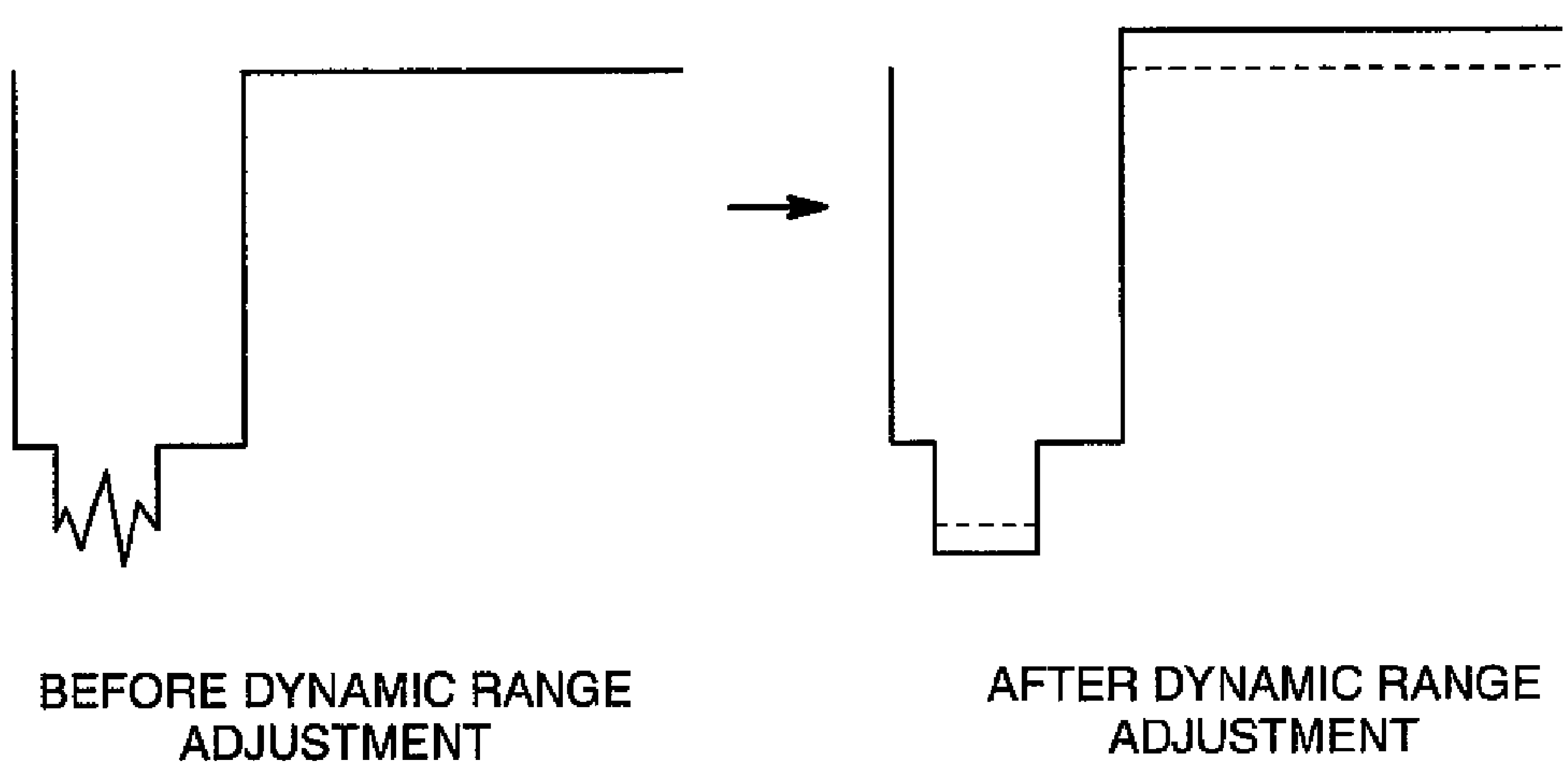
FIG. 4



Related Art
FIG. 5



Related Art
FIG. 6A



Related Art
FIG. 6B

AUTOMATIC GAIN CONTROL CIRCUIT IN VIDEO SIGNAL PROCESSING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The disclosure of Japanese Patent Application No. 2007-265255 including specification, claims, drawings, and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an automatic gain control circuit used in processing of a video signal.

2. Description of the Related Art

In a video signal processing device which displays a video signal of NTSC system (composite video signal) as a video image, there is used an automatic gain control circuit which amplifies a video signal to a certain level in an analog-to-digital converter in order to maintain a dynamic range of the brightness of the video image approximately constant.

As shown in FIGS. **3** and **4**, a video signal S_{IN} of one field includes a vertical synchronization period T_V, a horizontal blanking period T_H, and a video signal period T_S. The video signal S_{IN} of one horizontal line includes a horizontal blanking period T_H, a color burst period T_C, and an effective video signal period T_I. In FIGS. **3** and **4**, in order to simplify explanation, the video signal S_{IN} is displayed with the ratios among periods of the video signal S_{IN} differing from those of the actual video signal S_{IN}.

As shown in FIG. **5**, an automatic gain control circuit **100** of related art comprises an analog-to-digital converter (A/D converter) **10**, a front end block **12**, an automatic gain control circuit (AGC circuit) **14**, and a pulse width modulation circuit (PWM circuit) **16**. A video signal which is input to the A/D converter **10** is converted from an analog signal to a digital signal. In this process, according to a width of a pulse which is input from the PWM circuit **16**, the dynamic range of the digital conversion is adjusted. The digitized video signal is output to the front end block **12**. At the front end block **12**, a pre-process for the video signal is executed. The pre-process includes processes such as, for example, filtering and Γ correction. The video signal passing through the front end block **12** is input to the AGC circuit **14**.

The AGC circuit **14** extracts a signal level of the horizontal blanking period T_H of the video signal and outputs the signal level to the PWM circuit **16**. The PWM circuit **16** generates a pulse signal having a pulse width which is proportional to the input signal level, and outputs the pulse signal to the R/D converter **10**. As shown in FIG. **6**A, the A/D converter **10** adjusts the dynamic range according to the pulse width of the pulse signal and digitizes the video signal. In this manner, the level of the video signal is fed back to the A/D converter **10**, and the dynamic range of the video signal is maintained approximately constant. Such adjustment of the automatic gain control is executed in an initial adjustment process performed after a manufacturing process of the video signal processing device.

However, as shown in FIG. **6**B, the signal level in the horizontal blanking period T_H of the video signal may vary due to an influence of noise or the like. In this case, if the dynamic range of the A/D converter **10** is determined by reference to the signal level of the horizontal blanking period T_H, the dynamic range of the video signal cannot be appropriately adjusted.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided an automatic gain control circuit which receives a video signal including a black level which indicates a minimum brightness of a video image and a white level which indicates a maximum brightness of the video image, the automatic gain control circuit comprising a black level detecting unit which detects the black level from the video signal, a white level detecting unit which detects the white level from the video signal, and an analog-to-digital converter which adjusts a dynamic range of the video signal based on a difference value between the black level and the white level, wherein a signal level of the video signal is automatically adjusted.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiment of the present invention will be described in detail by reference to the following figures, wherein:

FIG. **1** is a block diagram showing a structure of an automatic gain control circuit in a preferred embodiment of the present invention;

FIG. **2** is a diagram showing a video signal for adjustment in a preferred embodiment of the present invention;

FIG. **3** is a diagram showing a structure of a video signal;

FIG. **4** is a diagram showing a structure of a video signal;

FIG. **5** is a block diagram showing a structure of an automatic gain control circuit in the related art;

FIG. **6**A is a diagram for explaining an automatic gain control process of the related art; and

FIG. **6**B is a diagram for explaining an automatic gain control process of the related art.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. **1**, an automatic gain control circuit **200** of a preferred embodiment of the present invention comprises an analog-to-digital converter (A/D converter) **20**, a register **22**, a front end block **24**, and a calibration unit **26**.

Adjustment of the automatic gain control of the video signal by the automatic gain control circuit **200** is executed during the initial adjustment process performed after the manufacturing process of the video signal processing device. In the initial adjustment process, a set signal is input from the outside to the register **22** and the calibration unit **26** so that the register **22** and the calibration unit **26** are set to an active state.

The A/D converter **20** receives an analog video signal from the outside, converts the analog video signal into a digital signal, and outputs the converted signal. The A/D converter **20** sets a reference voltage for the digital conversion according to a value stored in the register **22**, and adjusts the dynamic range of the video signal converted to a digital signal by matching the black level of the video signal to the reference voltage during digital conversion of the video signal.

The front end block **24** receives the video signal converted into the digital signal by the A/D converter **20**, and applies a pre-process for the video signal. The pre-process includes processes such as, for example, filtering and Γ correction.

The calibration unit **26** comprises a synchronization signal detecting unit **30**, a black level detecting unit **32**, a white level detecting unit **34**, a level calculating unit **36**, a target level setting unit **38**, a subtractor **40**, a correction value calculating unit **42**, an adder **44**, a gain calculating unit **46**, and a pulse width modulation unit (PWM unit) **48**.

The synchronization signal detecting unit **30** receives the video signal from the A/D converter **20**, detects the horizontal blacking period T_H, and outputs the horizontal synchronization signal Hsync at the detected timing to the black level detecting unit **32** and the white level detecting unit **34**.

The black level detecting unit **32** receives the video signal from the A/D converter **20**, detects a black level which indicates a minimum brightness in the video signal, and outputs as a black level signal to the level calculating unit **36**. During adjustment of the dynamic range, a video signal for adjustment is input. As shown in FIG. **2**, the video signal for adjustment indicates a minimum brightness Smin and a maximum brightness Smax in the video signal at timings which are predetermined periods T**1** and T**2** after the horizontal blanking period T_H. The black level detecting unit **32** receives the horizontal synchronization signal Hsync from the synchronization signal detecting unit **30**, extracts the black level (minimum brightness Smin) from the video signal at a timing which is the time period T**1** after the timing of reception of the horizontal synchronization signal Hsync, and outputs a black level signal to the level calculating unit **36**.

The white level detecting unit **34** receives the video signal from the A/D converter **20**, detects a white level which indicates the maximum brightness in the video signal, and outputs a white level signal to the level calculating unit **36**. The white level detecting unit **34** receives the horizontal synchronization signal Hsync from the synchronization signal detecting unit **30**, extracts the white level (maximum brightness Smax) from the video signal at a timing which is the time period T**2** after the timing of reception of the horizontal synchronization signal Hsync, and outputs the white level signal to the level calculating unit **36**.

The level calculating unit **36** detects a difference between the black level signal which is input from the black level detecting unit **32** and the white level signal which is input from the white level detecting unit **34**, and outputs the difference to the subtractor **40**. The difference value indicates a difference value between the maximum brightness Smax and the minimum brightness Smin of the video signal for adjustment; that is, a dynamic range of the video signal which is currently being output from the A/D converter **20**.

The subtractor **40** calculates a difference between the difference value which is output from the level calculating unit **36** and a target value of the dynamic range which is set in the target level setting unit **38**, and outputs the difference to the correction value calculating unit **42**. In the target level setting unit **38**, a target value of the dynamic range required as the video signal to be output from the A/D converter **20** is set in advance. In other words, a difference between the dynamic range of the video signal which is currently being output from the A/D converter **20** and a target value of the dynamic range is input to the correction value calculating unit **42**.

The correction value calculating unit **42** receives the output of the subtractor **40**, calculates a correction value of the gain corresponding to a difference between the dynamic range of the video signal which is output from the A/D converter **20** and the target value of the dynamic range, and outputs the correction value to the adder **44**. The adder **44** calculates a sum of the correction value from the correction value calculating unit **42** and the output of the gain calculating unit **46**, and outputs the sum to the gain calculating unit **46**. The gain calculating unit **46** determines a new gain value based on the output from the adder **44** and outputs the new gain value to the PWM unit **48**. In this manner, in the correction value calculating unit **42**, the adder **44**, and the gain calculating unit **46**, there is determined a new gain value corresponding to the difference between the dynamic range of the video signal which is output from the A/D converter **20** and the target value of the dynamic range.

The pulse width modulation unit **48** receives the gain value from the gain calculating unit **46**, generates a pulse signal having a pulse width corresponding to the gain value, and outputs the pulse signal to the register **22**. For example, the pulse width modulation unit **48** generates a pulse signal having a pulse width which is proportional to the gain value. The register **22** stores and maintains the pulse width of the pulse signal, and outputs the pulse width to the A/D converter **20**.

In this manner, a new gain value corresponding to the difference between the dynamic range of the video signal which is output from the A/D converter **20** and the target value of the dynamic range is fed back to the A/D converter **20**, so that the dynamic range during digitization of the video signal gradually reaches the target value.

At the completion of the initial adjustment process, the supply of the set signal from the outside to the register **22** and the calibration unit **26** is stopped, and the register **22** and the calibration unit **26** are set in a non-active state. With this process, the pulse width of the pulse signal corresponding to the gain value which is adjusted in the initial adjustment process is stored and maintained in the register **22**, and, after completion of the initial adjustment process, the analog-to-digital conversion by the A/D converter **20** is executed in an ideal dynamic range.

As described, according to the preferred embodiment of the present invention, the dynamic range of the A/D converter can be appropriately adjusted regardless of the level of the horizontal blanking period T_H of the video signal.

What is claimed is:

1. An automatic gain control circuit for receiving a video signal including a black level which indicates a minimum brightness of a video image and a white level which indicates a maximum brightness of the video image more than one time within one horizontal period and automatically adjusting a signal of the video signal, the automatic gain control circuit comprising:

a black level detecting unit which detects the black level from the video signal;

a white level detecting unit which detects the white level from the video signal; and

an analog-to-digital converter which adjusts a dynamic range of the video signal based on a difference value between the black level and the white level;

a level calculating unit which calculates a difference between the black level detected by the black level detecting unit and the white level detected by the white level detecting unit;

a subtractor which calculates a difference between the difference calculated by the level calculating unit and a target value of the dynamic range of the video signal; and

a gain determining unit which determines a target gain based on the difference calculated by the subtractor, wherein

the analog-to-digital converter adjusts the dynamic range of the video signal based on the target gain determined by the gain determining unit.

2. The automatic gain control circuit according to claim **1**, further comprising:

a pulse width modulation circuit which generates a pulse signal having a pulse width corresponding to the target gain determined by the gain determining unit, wherein

the analog-to-digital converter adjusts the dynamic range of the video signal based on the pulse width of the pulse signal generated by the pulse width modulation circuit.

* * * * *